NCE LIBRARY

JUL 1 3 1929

Vol. 26, No. 6 PSYCHOLOGICAL REVIEW PUBLICATIONS June, 1929

Psychological Bulletin

EDITED BY

SAMUEL W. FERNBERGER, Univ. of Pennsylvania

HOWARD C. WARREN, Princeton University (*Review*)
RAYMOND DODGE, Yale University (*Monographs*)
MADISON BENTLEY, Cornell University (*J. of Exp. Psych.*)
WALTER S. HUNTER, Clark University (*Index*)
HERBERT S. LANGFELD, Princeton University, *Business Editor*

WITH THE CO-OPERATION OF

G. W. ALLPORT, Dartmouth College; J. E. ANDERSON, University of Minnesota; J. E. COOVER, Stanford University; W. T. HERON, University of Minnesota; K. S. LASHLEY, Chicago, Ill.; M. F. MEYER, University of Missouri; J. T. METCALF, University of Vermont; R. PINTNER, Columbia University; E. S. ROBINSON, Yale University.

ANIMAL PSYCHOLOGY NUMBER

EDITED BY
W. T. Heron

CONTENTS

General Review and Summary:
Spontaneous Activity: M. Shirley, 341.
Special Reviews: 366.
Discussion: The Influence of Letter Position on the Range of Apprehension—A Reply to Dr. Tinker: H. R. Crosland, 375.
Books Received: 378.
Notes and News: 380.

PUBLISHED MONTHLY
For The American Psychological Association
BY THE PSYCHOLOGICAL REVIEW COMPANY
372-374 BROADWAY, ALBANY, N. Y.
AND PRINCETON, N. J.

Entered as second-class matter at the post-office at Albany, N. Y., September 25, 1922

Psychological Review Publications
of the
American Psychological Association

EDITED BY

HOWARD C. WARREN, PRINCETON UNIVERSITY (*Review*)
MADISON BENTLEY, CORNELL UNIVERSITY (*J. of Exp. Psych.*)
RAYMOND DODGE, YALE UNIVERSITY (*Monographs*)
SAMUEL W. FERNBERGER, UNIV. OF PENN. (*Bulletin*)
WALTER S. HUNTER, CLARK UNIVERSITY (*Index*)
HERBERT S. LANGFELD, PRINCETON UNIVERSITY, BUSINESS EDITOR.

WITH THE CO-OPERATION OF
MANY DISTINGUISHED PSYCHOLOGISTS

PSYCHOLOGICAL REVIEW

containing original contributions only, appears bi-monthly, January, March, May, July, September, and November, the six numbers comprising a volume of about 500 pages.

PSYCHOLOGICAL BULLETIN

critical reviews of books and articles, psychological news and notes, university notices, and announcements, appears monthly, the annual volume comprising about 720 pages. Special issues of the BULLETIN consist of general reviews of recent work in some department of psychology.

JOURNAL OF EXPERIMENTAL PSYCHOLOGY

containing original contributions of an experimental character, appears bi-monthly, February, April, June, August, October, and December, the six numbers comprising a volume of about 500 pages.

PSYCHOLOGICAL INDEX

is a compendious bibliography of books, monographs, and articles upon psychological and cognate topics that have appeared during the year. The INDEX is issued annually in June, and may be subscribed for in connection with the periodicals above, or purchased separately.

PSYCHOLOGICAL MONOGRAPHS

consist of longer researches or treatises or collections of laboratory studies which it is important to publish promptly and as units. The price of single numbers varies according to their size. The MONOGRAPHS appear at irregular intervals and are gathered into volumes of about 500 pages.

ANNUAL SUBSCRIPTION RATES

Review: $5.50 (Foreign, $5.75). **Monographs:** $6.00 per volume (Foreign, $6.30).
Journal: $6.00 (Foreign, $6.25). **Psychological Index:** $4.00.
Bulletin: $6.00 (Foreign, $6.25).
Current numbers: **Review** or **Journal**, $1.00; **Bulletin**, 60c.
Review and Bulletin: $10.00 (Foreign, $10.50).
Journal and Bulletin: $11.00 (Foreign, $11.50).
Review and Journal: $10.00 (Foreign, $10.50).
Review, Bulletin and Journal: $15.00 (Foreign, $15.75).
Review, Bulletin, Journal, and Index: $18.00 (Foreign, $18.75).

Subscriptions, orders, and business communications may be sent direct to the

PSYCHOLOGICAL REVIEW COMPANY
PRINCETON, N. J.

Vol. 26, No. 6 June, 1929

THE

PSYCHOLOGICAL BULLETIN

SPONTANEOUS ACTIVITY

BY MARY SHIRLEY

University of Minnesota

Spontaneous activity is one of the far-reaching problems of biology. The property of movement is one of the fundamental differences between plants and animals. Indeed the extent to which the animal has been able to achieve control over his environment is probably dependent in a large measure on his ability to migrate from place to place. Most animals expend far more energy than is actually necessary to keep themselves fed, warm, and out of harm's way. Vegetative animals are rare, and "animal spirits" as expressed in frolicsome activities which are not for the moment productive of food and shelter are the rule rather than the exception not only for lower animals but for human beings as well.

Much, if not most, of the activity of animals and children is spontaneous; by this term is meant simply that the stimulus or "drive" for activity comes from within the organism rather than from without. For this reason activity or playfulness often serves as a valuable index to the physical vigor of both animals and children. It is also highly probable that activity has an influence on the general behavior of the animal,—on his ability to learn, for example, or on his ability to meet a sudden crisis. Recognizing the importance of these implications of the problem of spontaneous activity, several physiologists and psychologists in recent years have set about studying the problem in its various phases.

A. Methods of Measuring Activity

The technique for activity studies is simple, not to say crude, in comparison to the refinements of methods for studying metabolism,

a physiological problem closely allied to that of activity. Three general types of activity recording apparatus have been used by experimenters, the tambour cage or platform, the revolving drum, and pedometers.

Stewart (**54**) in 1898 was the first to use revolving drums of the squirrel-cage type for measuring activity. This apparatus, described more fully by Slonaker (**45**), has been used by most experimenters who have worked with rats as subjects, among them Richter and his colleagues at Johns Hopkins, Hoskins and his group at Ohio State, and Lashley and the author at Minnesota. These cages are most successfully used for mice and rats and Bast (**3**) has even used them for exhaustion studies on rabbits. The chief advantage of the drum method is that automatic counters are attached to each cage which register each turn of the drum in either direction. Thus the results are quantitative. Shirley (**40**) has shown that the activity records are reliable when submitted to statistical analysis.

Szymanski (**55**) devised the tambour-mounted cage for recording activity. These cages or platforms are usually mounted on or suspended from a spring which rests on a tambour. The tambour is connected with another Marey tambour which records on a slow-moving kymograph. Richter and Durrant have used cages of this sort for rats, and Wada has used cribs and beds built on the same principle for babies and adults. An elaborate modification of this type of activity cage has been made by H. M. Johnson for use in his studies of sleep. This type of apparatus has the advantage that the distribution of activity periods over a given day or night and the exact hour at which each active period occurs are automatically registered, but these activity records cannot be used for a quantitative study of the total amount of activity.

Quantitative records of activity are also obtainable from pedometer records. Hodge (**19**) first used them in 1896 on dogs. Recently Liddell (**28**) found these instruments satisfactory for recording the activity of sheep. Attempts have been made to use them on children both at the Merrill Palmer Institute and at the Minnesota Institute for Child Welfare, but with very little success.

B. The Drive for Activity

The most extensive research on activity has been done in an attempt to find its internal stimulus. The factors of age, hunger and diet, and hormones all have been studied.

1. *Age and Activity*

Three age experiments have been conducted by Slonaker. In his first work (**44**) in which he used only four rats at four different age levels he found the animals to be most active between 87 and 120 days; but because of large individual variations he was unable to correlate the age of greatest activity with that of most rapid learning. In the second experiment (**46**) he ran four normal rats from birth to death, using as controls four rats at the same age and of a related litter which were kept in stationary cages. The activity of the group of runners increased during the first third of life and then gradually declined until death. These rats were most active at the age of 10 months. The unexercised controls lived longer, were heavier, and were less alert than the exercised rats. The one female was more active than any of the males; in the prime of life all of the rats ran more at night than at day.

Richter (**35**) has drawn up age-activity curves based upon rats of six different age levels upon which he took from 5- to 8-day records. He reports 100 days as the age of greatest activity and finds the 240-day rat less active than the 30-day rat. His work is open to criticism because he allowed only a 3-day preliminary period for the animals to accustom themselves to the drums. Most investigators agree that the preliminary period should be from 10 to 20 days long.

Shirley (**41**) presents material on age and activity based on 66 male rats, most of whom were in the cages successively from 2 to 8 or 10 months. She finds that the rats maintain a high level of activity from 5 to 9 months, that a group of rats varying two months in age will still be fairly homogeneous as to activity, that at the earlier ages, 2, 3, and 4 months, individual rats are inconsistent from month to month in activity, but from 6 months on each maintains his place within the group quite consistently, and finally that young rats (40 days) adjust to the cages more quickly but subsequently are more erratic in their performance than animals introduced into the cages at 100 days.

2. *The Hunger Drive for Activity*

That hunger is the chief drive for daily activity is the thesis put forth by Richter (**35**) and by Wada (**59**). Richter kept each experimental rat in a tambour-mounted living cage from which an alley led into another tambour-mounted cage in which food was kept. Thus activity in the living cage and that in the food cage were re-

corded in two parallel lines on the kymographic record. His tracings show that the rat grew restless at frequent intervals; during the restless period it entered the food cage, presumably ate, and returned to the nest-cage again. He believes that these rhythmic periods of activity correspond to the rhythms of stomach contractions. Wada used human infants and adults as her subjects. When stomach contractions, which were registered by means of a stomach balloon, were recorded parallel to the activity record they were found to be coincident with active periods or " stirs " in the sleep of the subject. Powelson (**34**) has further confirmed the fact that activity and stomach contractions occur simultaneously by direct observation of rats, the stomachs of which had been transplanted outside the abdominal muscle walls and were covered only by the layer of skin. He observed that as a rule the muscular activity immediately preceded rather than followed the waves of gastric contractions. Shirley (**41**) also found that animals which were fed only once a day were most active in the hour just before feeding, at which time their hunger contractions presumably would be very strong.

3. *The Hormone Drive to Activity*

The many discoveries of late years of the rôle played by internal secretions in growth and vigor has been a great impetus to work in spontaneous activity. The ease with which the rat's vigor can be measured in the activity drum has made it fairly simple to study the effects of many hormones on the animal's general well-being. Slonaker, Hoskins and his associates, and Wang have made the influence of internal secretions their chief study within the last few years.

(a) *Sex hormones (female)*

Wang (**60**) established the fact that the four-day rhythm in the activity of the female rat corresponded to the œstrual rhythm, and confirmed the coincidence of the peak of activity with the œstrum by an examination of the vaginal smears. Slonaker (**47, 48**) inferred that this was an œstrual rhythm by noting that such four-day fluctuations did not occur in the activity of males nor in that of the females before puberty or after the menopause.

He observed further that if mating occurred at the œstrum the activity of the animal dropped sharply from about 15,000 revolutions on the day of mating to the region of 2,000 on the day following. Activity then remained at a low level throughout the entire period of gestation and lactation. On the twentieth day of lactation, at which

time the œstrus cycle is usually reëstablished, activity rose and continued to rise until the young were weaned. Slonaker also checked the concurrence of the œstrum and high activity by the vaginal smear method of Long and Evans.

Durrant (**8**) discovered that the hormone which is responsible for the cyclic swing in activity as well as for the œstrual rhythm is an ovarian hormone, since hysterectomy effects only a temporary fall in activity which is most probably due to the operation alone. All investigators find that ovariectomy causes an immediate drop in activity to the level of that of male castrates and of females which have passed the menopause.

Miley (**31**) showed that the decreased activity which characterizes spayed female rats is due to an actual incapacity of the muscle for prolonged work. After ovariectomy the experimental animals decreased 82 per cent in activity as compared to their preoperative level of running. Ergographic studies of the work done by the gastrocnemius muscles of both the control and the spayed animals showed that the absolute strength per gram of muscle was 40 per cent greater for the controls, and the total work done by the muscles of the ovariectomized animals was only one-third that of the controls.

Wang and Guttmacher (**62**) found a variable effect from the removal of one ovary and severe traumatization of the other. Some animals completely lost the rhythmic activity cycles and became very inactive; some regained normal activity and œstrual rhythms; some regained normal activity but failed to reacquire the rhythms; and some regained the normal activity and maintained it permanently, but regained the œstrual cycles only for a short time. Histological examinations of the injured ovaries showed somewhat different pictures for each sub-group, but in all cases where the œstrual activity rhythms and smears had been restored follicular cysts were present. The only cells consistently found in these cysts were the granulosa cells. Consequently the authors have narrowed down the probable hormone which produces the increased activity at the œstrum and the cornification of vaginal cells and the hypertrophy of the uterine wall which are the other phenomena of the œstrum to a secretion from the granulosa cells of the follicular cysts.

The potency of the follicular hormone to restore the œstrual activity rhythms and the cyclic changes in the vaginal cells of the ovariectomized rats was demonstrated by Bugbee and Simond (**4**). They used the follicular fluid in subcutaneous injections and found that two injections daily over four successive days kept the animal

going through the rhythmic changes in the normal way. Tripling of the dosage, however, did not increase the activity level beyond that of the original dose. Ovarian extract was found to be impotent in increasing activity when it was fed by mouth. (Durrant, 6.) Hence this author concludes that the potency of the extract is destroyed by its passing through the digestive tract, and he believes that the beneficial effects which practitioners have reported on human subjects from feeding of ovarian extract is probably psychic. Slonaker's (52) results from the injection of follicular fluid into old female rats run counter to those of Bugbee and Simond in that he obtained a reduction rather than an increase in activity. The effect was transitory, however. He believes that the drop in activity after the normal œstrum is to be attributed to the liberation of the follicular hormone and its rapid absorption, and that the rapid absorption of the fluid injected into old rats would reinstate the normal conditions and cause the sudden drop in activity.

It is difficult to reconcile the contradictory results of Durrant and Slonaker with those of Bugbee and Simond as to the potency of the hormone. The latter investigators were attempting to use the effect on activity as a method for standardizing the commercial follicular product, and the work which they reported was based on only one treated case. It is possible, however, that the discrepant results of the three workers are to be accounted for in slight differences in the methods or in the dosage with the extract.

Although the corpus luteum hormone has been considered by many to act as an antagonist to the follicular hormone, Durrant (7) obtained no effect on activity from the subcutaneous injection of an aqueous extract of corpus luteum. He believes that the corpus luteum antagonizes ovulation but does not prevent the formation of the follicular hormone nor the development of ova.

Wang, Richter, and Guttmacher (61) demonstrated that ovarian transplants into castrated males increased the activity of 17 out of 24 animals in varying amounts over the pre-castrate level. Five animals reached activity levels equal to those of females, and four showed œstrual activity rhythms. Histological studies showed normal ovarian tissue in all the grafts from animals which had shown increased activity. The evidence, then, is good that the hormone which causes the œstrual rhythm and its accompanying activity cycle is the follicular hormone, which is probably secreted from the granulosa layer of cells.

(b) *Sex hormones (male)*

Male rats show no activity rhythm corresponding to the œstrual rhythm in females, and on the average they are considerably less active than females. Castration reduces their activity to a very low level. (Hoskins, 20). That the effect of complete castration differs according to the age at which the castration is done was shown by Gans (13). Although castration of the adult rat causes a five-fold decrement in activity, the castration of rats between 1 and 11 days in age produces no subsequent impairment in activity. Using the method of fractional castration Gans (14) further showed that the impairment in activity caused by castration was directly proportional to the amount of the testicles removed. Gans and Hoskins (11) proved that the muscle of male castrates fatigues more easily than that of normal males. The method, identical with that later used by Miley on ovariectomized females, involved testing the strength and fatiguing the gastrocnemius muscle in situ by work on an ergograph. Although the weight of individual muscles was greater in the castrates the absolute strength per gram of muscle tissue averaged the same for castrates and controls, and the proportion of gastrocnemius weight to total body weight was the same for both groups. The authors are in doubt as to whether the greater fatiguability of the muscle of castrates is to be attributed to impairment of the muscle tissue itself, or to a failure of the circulatory and respiratory functions in the castrates.

Both Hoskins (21) and Richter and Wislocki (38) have tried the effects of testicular grafting on the activity of castrates, the former with no effect on activity whatever, and the latter with some slight effect on 8 out of 36 cases. Richter and Wislocki transplanted the testes in both castrated males and females; the castration and transplantation of testes were done in a single operation when the animals were young. Seven of the males and two of the females showed functional takes by an increase in activity, but this increase was less than in the case of ovarian transplantation. Histologically six of the functional takes showed well preserved grafts in which the interstitial tissue was not degenerated. The authors attribute the hormone secreting function to the interstitial cells.

Hoskins (22), having failed to bring castrated animals back to a normal activity level by the granting of testes, decided that the depression of castration might involve a vicious cycle, laziness tending to make the animals fat, and fatness tending to make the animals lazy. Consequently he set about bringing them back to normal activity

through starvation. After a 4- to 6-day starvation period he obtained an increase of about 200 per cent in activity, but in most cases this increase lasted only a few days after full feeding was resumed.

(c). *The adrenals and activity.*

Considering the extensive work which has been done on the function of the adrenal glands in general it is surprising that so little has been done on the rôle of the adrenals in spontaneous activity. Perhaps the fact that the rat is the most desirable animal for activity studies, whereas the cat is the favorite for use in adrenal studies is partly responsible for the comparative neglect of this phase of the adrenal problem. It is well known, of course, that the rat usually has several nodules of accessory chromaffin tissue distributed along the aortic path; the impossibility of removing this tissue along with the adrenals makes epinephrectomy in the rat an unsure operation.

Durrant (5) studied the activity of 21 rats which survived double epinephrectomy. Although the animals appeared normally active to the casual observer, yet over a period of hours or days they proved to be very much less active than the severely traumatized control animals. Again Gans and Miley (12) showed by ergographic studies that the muscle of the animal with adrenals removed was very much less efficient than that of the normal animal; although the absolute strength per gram of muscle was essentially the same for both groups, the muscles of the experimental animals fatigued in from 10 to 60 minutes, whereas the normal muscles worked on from 8 to 26 hours. The total work done by the experimental group was only $^1/_{16}$ that of the controls.

(d) *The thyroid and activity*

The work on the rôle of the thyroid in activity is slightly more extensive than that for the adrenal. Since hyperthyroidism is usually accompanied by increased nervous irritability and hypothyroidism is associated with lethargy one might expect to obtain marked increase in activity from thyroid feeding. Wang (63) fed desiccated thyroid in 2, 4, and 8 grain doses mixed with 100 grams of food. Thus the thyroid dosage depended upon the amount of food eaten. The thyroid rats ate more and weighed less, and showed increased heart rate and body temperature, but they exhibited a marked loss in activity. Hoskins (23) likewise found a depressing effect on activity from feeding thyroid in large amounts to senile animals, but observed no influence of the hormone when it was fed in small doses.

Lee and VanBuskirk (27) observed no change in the activity of 18 rats during a three-month period after thyroidectomy. Although the hypothyroid symptoms were definitely present there was no lethargy. The feeding of thyroid to 6 young females was accompanied by a slight decrease in activity. These authors discuss the relation of basal metabolism to activity. Although thyroidectomy decreases metabolic rate it apparently has no effect on activity; conversely thyroid feeding, which increases metabolism, depresses activity. Castration, which affects activity to such a large degree, does not alter metabolism, and the œstrual changes in metabolic rate do not correspond to the activity changes. Even though this evidence is indirect, yet it seems logical to conclude that there is no relation between basal metabolism and activity.

Liddell and Simpson (29) who used the pedometric method of recording the activity of normal and thyroidectomized sheep, found that the spontaneous activity of the cretins was increased following thyroid treatment after a latent period of from 3 to 8 days. Sodium-iodide treatment was ineffectual on the cretin sheep.

The effects of the endocrines on activity has been ably summarized by Hoskins (**24**). In addition to the works reviewed above he reports that the administration of pituitrin to inactive rats produced no effect, and that negative results were obtained from work on the parathyroids. As yet no experimental work has been done on the pineal gland and the pancreas.

4. *The Relation of Blood Sugar to Activity.*

Shirley (**42**) determined blood sugar on 45 cases on which activity had previously been determined. Blood sugars were done according to Folin's most improved methods. A high sugar group, averaging 112 mgm. per 100 c.c. of sugar had an average activity of 3,500 revolutions, whereas the low sugar group, averaging 82 mgm. per 100 c.c. averaged 5,800 revolutions in activity. The correlation between blood sugar and activity was —.20. Which factor is cause and which is effect in this slight relationship between the two factors is hard to determine.

5. *Drives for Activity: Summary.*

From the work of these investigators it would seem that hunger pangs serve as the daily drive to activity in rats. In both males and females a sex hormone, probably secreted by the graafian follicles in the females and by the interstitial tissue in the males, determines the

general level of activity for each sex. Furthermore, the autocoid in the female animals produces activity of a cyclic character which follows the œstrual rhythm, the peak of activity occurring at the œstrum. A secretion from the adrenals also enters into the complex of factors which affect activity. The rôle of the thyroid in activity is doubtful or negligible. There is some evidence that the drive to activity is actually the efficiency or state of well-being of the muscular system, or of its supporting functions, since the fatigue studies showed that the muscles from the less active animals were capable of much less work. In other words, although the rat may not work spontaneously up to the limit of his capacity yet he probably does perform in proportion to his actual muscular strength.

C. Factors Which Modify Activity

For the experimenter who has practical ends in view it is important to know to what extent activity can be modified without tampering with any of the primary drives to activity discussed above. The effects of diet, drugs, fatigue, rest, brain injury, and other factors have been studied extensively.

1. *Activity as Conditioned by Diet.*

Diet studies are second in frequency only to hormone studies in the activity literature. Stewart (**54**) observed that animals were most active on a simple but adequate, in quantity at least, diet of bread. On dog biscuit they were slightly less active, and on bread and beef they decreased considerably in activity.

Slonaker (**47**) put 8 rats on a strictly vegetable diet. The diet of the experimental rats was table scraps and corn; that of the controls was the same with meat added three times a week. Occasionally when the vegetarians seemed to be losing ground they were given milk or cheese. At the end of 19.8 months, their average life-time, the vegetarians had done only as much work as the omnivorous feeders had done at the age of 6.2 months. Slonaker estimates the ratio in efficiency of the omnivorous to the vegetarian rats as 5:1. The omnivorous feeders lived longer, weighed more, and were generally healthier.

It seems probable from Slonaker's description of a dry, scaley skin disease which the vegetarians contracted that the omnivorous feeders did not take that the vegetarian animals were the victims of pellagra, a protein-deficiency disease. A scrutiny of the sample diets

given reveals that in the spring an ample quantity of lettuce, nuts, and legumes were fed, but that in the fall cereals, especially corn, made up the bulk of the diet. This diet was probably somewhat deficient in vitamins. Furthermore most cereal proteins are deficient in some of the amino acids necessary for growth. Zein, the chief protein of corn, contains no lysine, tryptophan, or cystine, and is somewhat low in arginine and histidine, all of which amino acids are essential for growth of the young animal. Pellagra, a disease having as its symptoms dry skin and digestive disturbances is associated with a corn diet, and is thought to be due to a deficiency of tryptophan. The addition of other cereal proteins will not make the diet adequate for growth. It seems probable that Slonaker's vegetarian rats were thus diseased as well as stunted by an inadequate protein diet, a fact which might well account for the very low activity level of the vegetarian rats.

Less positive effects of meat protein on activity are reported by Hitchcock (16). McCollum's diet, supplemented at times by corn and cabbage, was kept constantly before the animals. In addition 8 grams of fresh lean meat cooked rare were added to the diet of the meat eaters. These experiments were continued over several months. No conclusions as to the effect of the meat diet on activity can be drawn. In some cases the activity of the meat eaters seemed to be depressed, and in others augmented. Recovery from a period of starvation was more rapid on the meat diet. Individual variations in activity are so great that the slight differences which Hitchcock found may be accounted for on that basis.

On a low vegetable protein diet (12 per cent protein, which is adequate for an animal's maintenance) Hitchcock (18) found that the activity of 11 experimental animals gradually dropped and for the last eight months was only 55 per cent as great as that of the normals. Complete protein starvation for 14 days effected an increase of 177 per cent in the activity of 15 adult male rats. Complete fasting for three days caused an increase of 44 per cent in the activity of 25 rats, but the animals immediately dropped to their former level of activity on the five days after the fast.

A slightly different diet study was made by Anderson and Smith (1, 2). Three groups of rats were used, a qualitatively stunted group in which gliadin, a wheat protein whose chief amino acid is glutamic acid, furnished the protein of the diet; a quantitatively stunted group which received only enough of the adequate diet to maintain weight at the original level; and a control group fed on

the same diet as the quantitatively stunted with casein replacing the gliadin, which factor made the diet adequate. Activity records of these animals were taken over 10-day periods by putting the animals in revolving cages for one hour a day. The normal rats decreased in activity as they advanced in age; both stunted groups were more active than normal animals of the same age. Since the activity method used in this experiment differs from that of most investigators, the results are not comparable with those of Slonaker and Hitchcock.

Hitchcock (17) computes that a completely inactive rat would consume approximately 855 calories per square meter of body surface, and he discovered that in adult rats kept in activity cages an increase in food consumption due to an increased activity is directly proprotional to the cube root of the activity as expressed in meters. Slonaker (49) found that a decreased activity of the female rat during gestation and lactation was accompanied by an increased food intake.

In summary, activity is best on a plain but adequate diet which contains the necessary proteins, fats, carbohydrates, salts, and vitamins for growth and maintenance. But there is no way of feeding a rat which will make him more active. Starvation, either complete or for proteins only, will increase activity but this treatment can be used only for very short intervals without doing permanent damage to the rat.

2. *The Effect of Drugs on Activity.*

(a) *Alcohol.*

One of the earliest attempts to measure spontaneous activity quantitatively was made by Hodge (19) in a study of alcoholism. The activity of a male and a female alcoholic dog was compared with that of their normal brother and sister. A modified pedometer was attached to the collar of each dog. The activity of the alcoholic male was 72 per cent of that of his brother; that of the alcoholic female was only 57 per cent that of her sister.

Stewart (54) administered alcohol to three pairs of rats in strengths of 60 per cent, 30 per cent, and 20 per cent respectively. Over a period of about six months he found a marked decrease in activity of the rats fed on strong solutions, but no effect from the 20 per cent solution. Such effects were not apparent in the activity curves till after the thirtieth alcoholic day. Nice (32) gave mice only 35 per cent alcohol to drink and fed 3 c.c. of 35 per cent alcohol in the animal's food each day. Both the four alcoholic animals and the four controls gained continuously in activity throughout the 36

weeks of the experiment. The totals for the alcoholic mice were, however, lower than those for the controls. "It appears," he says, "that alcohol has a markedly injurious effect on the viability and activity of mice, and that these effects are cumulative."

Richter's (**36**) work on alcohol enables him to draw less sweeping conclusions. He fed 8 per cent, 10 per cent, and 16 per cent alcohol to three different groups of rats; the rats were fed on a dry diet and the alcohol supplanted the drinking water. The supply of alcohol was kept in graduated watering tubes from which evaporation was negligible and the amount of alcohol taken by each rat each day was read along with the activity cage readings. The food consumption for the alcoholics was less than that for the controls. When the calories for the alcohol drunk by each rat were computed it was found that the alcohol exactly made up the calorie deficiency in the amount of food consumed. With two exceptions the control animals ran higher activity records than the alcoholics. Richter believes that alcohol has a depressant effect on activity. But the number of cases is few and the results are by no means clear cut. Richter does not comment on a fact which is apparent from a study of his tables, namely that the female animals seemed to be less affected by the alcohol than the males. In some unpublished work the present author noted the same fact; female animals decreased less under alcoholic feeding than did male rats. Further work might be of interest on this point. If it were verified on a large number of cases the explanation would probably lie in the fact that since female rats are normally more active than males they burn up the alcohol more rapidly and thus its effect does not linger so long as on males.

(b) *Nicotine.*

Nice (**32**) likewise studied the effect of nicotine on the activity of his mice. The mice were given a 1:1000 solution of nicotine sulphate to drink instead of water and had 3 c.c. of the solution added to the food. The average total activity for the nicotine-fed animals over a period from 8 to 36 weeks was almost the same as that of the normals. Three of the animals seemed to be stimulated by the nicotine, although the author thinks that possibly the effects were due to chance.

The immediate effects of tobacco smoke on the activity of rats has been studied by Field (**10**). Although the rats were quiescent during the 7 minute period in the air-tight smoke cage they were more active for a period ranging from 15 to 45 minutes after being smoked.

(c) *Caffeine.*

Nice (32) found that caffeine fed in a 1:300 solution of caffeine citrate lessened the activity of the mice greatly. The curve for the caffeine-fed mice was lower than those for alcoholics, nicotine-fed, and controls.

(d) *Phosphates.*

The feeding of phosphates to soldiers yielded an encouraging increase in their endurance. (Embden, 9). In his preliminary work Embden had his subject drink 250 c.c. of a 4 per cent sugar solution containing 1 per cent of di-basic sodium phosphate. Later he increased the phosphate dosage from 2.5 grams to 7.5 grams a day. On control days the subject drank 4 per cent sugar water containing 1 per cent tartaric acid. The subject's endurance was tested by one hour's work on a treadmill. On phosphate days the amount of work done was appreciably greater than on control days. In most cases the greatest effect of the phosphate was noticed on the day after its consumption, but the effect of the dose was usually noticed within 6 hours after feeding. One subject complained of sleepless nights when the phosphate was taken in the evening. Phosphate feeding was then tried out on soldiers on the march. Each man received 7.5 grams per day. Not only were the phosphate-fed troops fresher than control troops in the same regiment after a long day's march, but they were also more alert when at rest. Some restlessness at night was noticed among them. But the greatest difference between the two groups, according to Embden, was psychic. Whereas the control-fed soldiers were dumb from fatigue after a day's advance, the phosphate-fed men shouted and sang gaily. Some phosphate feeding was done on horses, the dosage being 80 grams a day. Favorable results were noted.

At the suggestion of this work by Embden, Shirley (42) mixed 2 c.c. of a 5 per cent solution of Na_2HPO_4 with the food of each rat and fed this mixture over a 10-day period. The rats were given a bread and milk diet. Since milk is a food high in phosphates there is no reason to expect beneficial results from phosphate feeding such as might occur with animals whose diet was deficient in the salt. On 97 animals she obtained an average of 22 per cent gain in activity under the phosphate regime as compared to the control period on the same animals. She believes that the beneficial effects of phosphate feeding lie in the fact that the inorganic salt furnished phosphate in a readily available form for synthesis with glucose into hexosephos-

phate or lactacidogen. Since a large part of the body's reserve phosphate is stored in the bones, and since many of the body phosphates are in organic compounds they can be assembled to meet the demands of heavy muscular work only through the breakdown of other complex compounds. Some observers report, however, that excess phosphates are almost immediately excreted from the digestive tract; if this is true the above explanation breaks down.

(f). *Rest.*

The effect of enforced rest or inactivity on subsequent activity was studied by Shirley (41). After the animals had become perfectly accustomed to the activity drums she removed each to a small stationary cage which was just large enough for him to turn around in. The rats were kept in these rest cages for rest intervals of 1 day, 2 days, 3 days, and 5 days; after each rest period the animals were returned to the activity cages for a day of running. This procedure was continued over a 10-day period; as a control the records for the 5-day periods of continuous running just preceding and just following the rest period were used. Thus each rat acted as his own control. On the average the rats were benefited by rests of 1 or 2 day duration, but rest periods of longer duration impaired subsequent activity. The gain after rest was about 25 per cent. The cumulative effect of rest was, however, to impair activity. Active animals appeared to be more benefited by rest than inactive animals.

Kunde and Nordlund (25) did studies of the basal metabolism of dogs under conditions of normal activity, restricted activity and increasing amounts of activity following the restricted activity period. They found that the basal level was reduced by restriction of physical activity and was increased by daily exercise short of exhaustion. Their result is an exception to Lee's theory that activity and basal metabolic rate are unrelated.

(g) *Fatigue.*

Three studies by Gans, Miley, and Hoskins reported above suggest that the less subject an animal is to fatigue the more active he is. In other words inactivity is not just sheer laziness, but has an actual physiological basis. In their work on exhaustion due to lack of sleep Bast and Loevenhart (3) forced rabbits to be active until they died from exhaustion by keeping the revolving cages in which the animals lived constantly turning. The time required to fatigue the animals to death varied from 7 to 31 days. The general symptoms of collapse were a fall in body temperature, a fall in respiratory rate, and a rise

in pulse followed by a sudden marked fall. Histological examination of the nerve cells in the cord and in the medulla showed a decrease in chromatin material of the nuclei; chromatolysis occurred and was characterized by a granular appearance of the Nissl bodies, vacuoles in the cytoplasm midway between the cell wall and the nucleus, lighter staining of the nucleus, and a clustering of the material which stained closely about the nucleolus, which appeared normal. There appeared to be no change in the motor nerve cells supplying the somatic musculature.

Hoskins in his summary of the work on fatigue considers that the seat of fatigue is in the muscle itself or in the supporting respiratory or circulatory functions rather than in the nervous system. The work of Bast would seem to indicate nevertheless that fatigue is not unaccompanied by neural changes, though it is entirely possible that these changes which he observed are merely coincident with fatigue and are likewise due to a failure of the vascular and respiratory systems. We are still at a loss to know what wears out by fatigue which can be replaced by rest. But it is pretty certain that the normal animal will not fatigue himself spontaneously beyond the limits of easy recovery.

That enforced activity caused a marked irritability in young rats was discovered by Seham and Seham (**39**).[1] They subjected one group of rats to enforced activity for one hour a day by having the activity cages motor driven at a slow speed. These rats appeared to be much more affected by a multiplicity of disturbing stimuli such as flashing lights and sounding gongs; the control group of normally active animals was little affected by the distractions. Inanition was another factor which alone might have accounted for the increased irritability and the poor physical condition of the experimental rats. It was the object of the investigators to study the effects of malnutrition, over-stimulation, and fatigue combined; consequently the experimental animals were given insufficient food also. It is impossible to tell, therefore, which single factor is more responsible for the phenomena which occurred.

That enforced activity is responsible for at least part of the effects found by the Sehams, namely the stunting of growth, is certain from

[1] The writer discussed this work with the Sehams before they had completed the analysis of their data. For a more complete report of the experiment their forthcoming article should be consulted.

the work of Price-Jones (33). He forced young animals to activity in a revolving drum and found that their increase in weight and body length was retarded.

(g) *Sexual indulgence.*

Sexual indulgence tends to curb the total activity of the female rat according to Slonaker's (53) findings. He divided his rats into five groups according to the amount of sexual indulgence allowed them; group A had no sexual indulgence, group B were light breeders, group C, medium breeders, group D heavy breeders, and group E was a group of hysterectomized females which were constantly with the males, and whose activity, therefore, was not recorded. The animals were put into the activity cages at the age of seventy-two days. The activity records are based on the whole life-time of the rats. The virgin rats were the most active, having an average life run of almost 6,000 miles. Light breeders ran almost 4,000 miles, heavy breeders about 2,500 miles, and medium breeders slightly more than 1,500 miles. The activity varied directly with the amount of time spent in carrying and nursing the young. Hence no conclusions can be drawn as to the influence of sexual indulgence as such on the animals. It is to be regretted that Slonaker does not also present activity records for the five corresponding groups of males, since their activity would persumably be affected by the sexual indulgence alone. With regard to this point Richter (37) states that whereas the female rat is less active on the day after copulation, no such decrease is noted in the activity of the male. The more active males breed more frequently than the less active ones, he reports.

(h) *Cerebral injury.*

The theory that individuals with lesions in the frontal lobe are very restless and hyperactive has long been held. Lashley (26) discovered from activity records on rats that hemidecerebrate, occipital, and parietal cases had a lower average activity than normals, but frontal and fronto-parietal cases averaged higher. The small number of cases and great individual differences make the results uncertain.

(i) *Summary of factors which alter activity.*

Rats can be induced to greater activity for a short time by starvation, either quantitative or qualitative. Two drugs seem to act as stimulants to activity,—nicotine and sodium phosphate. Short periods of rest interspersed between days of activity also seem to

augment activity. Abstinence from sexual indulgence leads to greater activity in the female rat. Some brain lesions, notably those in the frontal lobe, appear to increase activity.

Factors which retard activity are malnutrition over long periods, prolonged dosing with alcohol and with caffeine, rest periods of more than two days length, excessive fatigue, gestation and lactation, and probably brain lesions in the occipital and parietal lobes. The work which has been done on these factors is in general based upon fewer cases and is less clear-cut as to results than that done on the drives to activity. Consequently the conclusions are less certain.

D. Traits of the Animal Which Are Dependent on or Modified by Activity

Many traits or habits both in animals and in human beings require a great amount of activity, or at least the expenditure of a great amount of energy. Since spontaneous activity seems to furnish an index to the general physical well-being of the animal and since individual differences in activity are very great it appears highly probable that the performance of animals in other traits is dependent to a very large extent on their activity alone. Consequently it behooves investigators of other traits to seek out the relationship between activity and the trait in question.

(a) *The relation of activity to maze learning.*

Maze learning is the only trait which has been investigated parallel to activity. The reasons for this are perhaps three: first, maze running is a trait which seems to require considerable activity and speed; second, maze running is the trait most frequently studied in the rat; and third, the rat is the animal most often used in activity studies.

Lashley (26) trained his operated animals in the maze. He found no clear relation between activity and learning. Liddell (30) attempted to correlate activity and maze learning in sheep. He was able to make 152 comparisons with respect to activity and proficiency in learning. From his data he discovered no definite or close relation between spontaneous activity and motor learning. He attributes this lack of relationship in part to the unreliability of the maze itself.

Anderson and Smith (1, 2) found in general that the stunted animals, which were more active than the normal animals, ran the maze in faster time but made more errors in their learning; after a given time, however, all animals reached the same level of proficiency.

The relationship found by Shirley (**43**), who trained 46 animals in a fairly reliable maze, was slight but in the expected direction. The correlation between activity and maze time was about —0.40, and that between maze errors and activity was much lower but in the negative direction.

These studies indicate that any relationship which exists between activity and maze performance is so slight that it can be ignored. But these negative results do not mean that the effect of activity on all other traits is inconsequential. What they may mean is that spontaneous activity, which probably is an index to the animal's total capacity for the output of energy, is not an index to the amount of energy which will be called out by any given incentive. In other words it is probable that the energy store of every animal is equal to the demands which will be made upon it, and that the amount of energy called out by any given incentive is much more nearly equal from rat to rat than is the energy which is spontaneously expended, or at least that it is not proportional to the total energy store.

E. Rhythmic Nature of Activity

(a) *Hunger rhythm.*

Richter (**37**) is convinced that the drive to activity is to be sought in an analysis of activity rhythms. To him goes the credit for the discovery of the 2-hour rhythm in activity, and for the proof of the relation between this rhythm and hunger contractions of the stomach. In an attempt to discover further rhythms which might be related to activity he studied the rhythmicity of the animal in drinking, in urinating, and in defecating.

(b) *Sex rhythms.*

Wang and Slonaker, whose works have been reviewed above, each discovered the association between activity and the 4-day œstrual rhythm in the female rats. No rhythm dependent upon sex function has been found in male rats.

(c) *Diurnal rhythms.*

The rhythmicity of activity has been the chief concern of Szymanski (**56, 57, 58**). He has charted the rest and activity periods on a large number of animals ranging up the animal scale from the cockroach to man. Szymanski divides animals into two classes according to activity, the monophasic and the polyphasic. The monophasic animals have only one prolonged period of activity in 24 hours which

corresponds more or less to the period of either darkness or daylight; the polyphasic animals, on the other hand, have several periods of activity a day which seem to be independent of diurnal changes.

Thus the cockroach is inactive during the day; most of its activity occurs during the evening hours. Although it is essentially a monophasic animal, Szymanski believes that inner stimuli are more potent than light and temperature factors in the activity of this animal. The goldfish is likewise monophasic in its activity; it is almost constantly in movement by day and at rest by night. The canary also is active by day and sleeps by night, although its nightly rest is somewhat more disturbed in winter than in summer. When the bird is kept in darkness both day and night its activity is somewhat diminished, but the daily rhythm, activity in the 12 hours from 6 A.M. to 6 P.M. and practically undisturbed rest from 6 P.M. to 6 A.M., still persists. The white mouse, according to Szymanski shows 16 rest and 16 activity periods, each about 45 minutes in length, throughout the 24 hours. Like that of the mouse, the activity of rabbits is typically polyphasic. The human infant shows about six fairly equally spaced periods of activity during the 24 hours. Whereas the cat's activity is largely nocturnal, that for the dog is diurnal, the most active hours coming in the forenoon.

Since these daily rhythms are characteristic for each animal, and since they are very little disturbed by changes in either temperature or illumination Szymanski believes that they are occasioned by internal physiological rhythms rather than by outside conditions.

The rat is usually considered as a nocturnal animal. In his earliest study Richter (35) did some experiments on illumination and activity. The animals were consistently more active in the dark, whether they were fed at the beginning of the light period or the dark period. Slonaker (50) in analyzing the hourly records of female rats over a period of 8 days observed that the rat was nocturnal, although there were wide variations in the hour at which the nightly run began. Maximum activity occurred between midnight and 4 A.M. These rats had food constantly before them. The activity of rats in early pregnancy, though much less than that of non-pregnant rats, was spread over many more hours of the day. In late pregnancy activity was again concentrated in the night hours. Shirley (41) found that rats which were fed once a day showed greatest activity in the hour just before feeding. Nevertheless a slight increase in activity was observed during the early night hours even though the rats were kept under conditions of constant temperature and illumination.

(d) *Long periodic rhythms.*

In addition to the daily and œstrual cycles, Slonaker (51) has also noted long fluctuations of weeks or even months duration. A virgin female exhibited 12 of these fluctuations throughout her lifetime, while three males had about 8. These fluctuations varied in number and length. Their lack of synchronism indicates, Slonaker says, that they are not due to changes in environment, such as temperature or humidity. These fluctuations persisted after the menopause in females and after senility in males. Richter and Hoskins also mention rhythms of long duration, and Shirley noted fluctuations in activity from time to time, but doubted the rhythmicity of their character. Hitchcock (15) thinks such fluctuations are seasonal; Shirley and Slonaker disagree. If such long period rhythms occur, however, and if it is certain that they are not correlated with temporary cases of nasal infection or similar diseases, they certainly should be taken account of in experimental work.

F. Individual Differences in Activity

All workers in the field of activity stress the fact of the great individual differences among apparently normal and healthy animals, but few have attempted to make a systematic analysis for the conditions which make for these differences. Shirley's analysis of blood sugar in relation to activity, and Gans' studies of fatiguability are suggestive of methods for attack.

1. *Sex Differences.*

Marked differences in the amount of activity of males and females have been pointed out by most workers. Hitchcock (15), in a comparison of 35 male and 36 female rats, found that the average activity of males was about 56 per cent of that of females. There was little difference in the daily variation of males and females; although the male rats showed no œstrual rhythm, yet the variation from day to day for both males and females was 50 per cent.

2. *Differences Among Litter-mates.*

No work has as yet been done on the hereditary nature of spontaneous activity although the problem is now under investigation by Rundquist at the University of Minnesota. Hoskins has repeatedly said that the use of litter-mates as controls for experimental animals is a useless precaution, and Hitchcock, in the article referred to above,

definitely states that greater variations in activity are often found between two rats of the same litter than between two rats of different litters.

3. *Differences in Type of Activity.*

An ingenious multiple activity cage has been devised by Richter (37) in which various types of activity can be registered simultaneously. The cage consists of a central living-cage, from which alleys lead to a nest-building cage, a gnawing cage, a burrowing cage, a climbing cage, a running cage, a sex cage, a food cage, and a drinking cage. Richter believes that such a cage offers a more normal environment for the rat than the ordinary laboratory cages, and that life in such a cage enables the animal to develop all his resources and capacities. He notes that there are great individual differences in the type of activity which is preferred by different animals. Some animals spend most of their time in climbing; others show greater activity in the gnawing or nest-building cages. In such a multiple cage the running is greatly reduced and the animal spends most of his time at other pursuits.

G. Summary

Through the study of spontaneous activity several drives to activity have been fairly well established. Few factors have been discovered which can modify normal spontaneous activity to any appreciable degree, and no trait or habit in which the proficiency acquired depends largely upon spontaneous activity has as yet been discovered. The study of rhythms in activity has led to the discovery of several activity drives. Individual differences in activity have been found to be great but the probable causes of such differences have not been adequately studied.

BIBLIOGRAPHY

1. Anderson, J. E., and Smith, H., The Relationship of Performance to Age and Nutritive Condition in the White Rat. Psychol. Bull., 1927, **24**, 177.
2. Anderson, J. E. The Effect of Quantitative and Qualitative Stunting upon Maze Learning in the White Rat. *J. Comp. Psychol.*, 1926, **6**, 337–359.
3. Bast, T. H., Lœvenhart, A. S., and others, Studies in Exhaustion Due to Lack of Sleep. *Am. J. Physiol.*, 1927, **82**, 121–145.
4. Bugbee, E. P., and Simond, A. E., The Increase of Voluntary Activity of Ovariectomized Albino Rats Caused by Injections of Ovarian Follicular Hormone. *Endocrinol.*, 1926, **10**, 349–359.
5. Durrant, E. P., Studies on Vigor. I. Effect of Adrenal Extirpation on the Activity of the Albino Rat. *Am. J. Physiol.*, 1924, **70**, 344–350.

6. DURRANT, E. P., Studies on Vigor. III. The Effect of Ovarian Extract Feeding on the Activity of Ovariectomized White Rats. *Endocrinol.*, 1925, **9**, 221–228.
7. DURRANT, E. P., Studies on Vigor. VIII. The Effect of Subcutaneous Injection of Corpus Luteum Extract on Voluntary Activity in the Female Albino Rat. *Endocrinol.*, 1926, **10**, 286–290.
8. DURRANT, E. P., Studies on Vigor. XI. Relation of Hysterectomy to Voluntary Activity in the White Rat. *Am. J. Physiol.*, 1927, **82**, 14–18.
9. EMBDEN, GRAFE, u. SCHMITZ, Über Steigerung der Leistungfahigkeit durch Phosphatzufuhr. *Hoppe-Seyler Zeit. f. Physiol. Chem.*, 1921, **113**, 67–107.
10. FIELD, H. E., The Immediate Effects of Tobacco Smoke on the Activity of Rats. *Univ. Cal. Publ. Physiol.*, 1926, **5**, 189–194.
11. GANS, H. M., and HOSKINS, R. G., Studies on Vigor. VII. The Fatigability of Castrated Rats. *Endocrinol.*, 1926, **10**, 56–63.
12. GANS, H. M., and MILEY, H. H., Studies on Vigor. IX. Ergographic Studies on Adrenalectomized Animals. *Am. J. Physiol.*, 1927, **82**, 1–6.
13. GANS, H. M., Studies on Vigor. XIII. Effect of Early Castration on Voluntary Activity of Male Albino Rats. *Endocrinol.*, 1927, **11**, 141–144.
14. GANS, H. M., Studies on Vigor. Effect of Fractional Castration on the Voluntary Activity of the Male Albino Rat. *Endocrinol.*, 1927, **11**, 145–148.
15. HITCHCOCK, F. A., Studies on Vigor. V. The Comparative Activity of Male and Female Albino Rats. *Am. J. Physiol.*, 1926, **75**, 205–210.
16. HITCHCOCK, F. A., The Effect of the Luxus Consumption of Meat upon the Voluntary Activity and Growth of the Albino Rat. *Am. J. Physiol.*, 1926, **79**, 206–217.
17. HITCHCOCK, F. A., The Total Energy Requirement of the Albino Rat for Growth and Activity. *Am. J. Physiol.*, 1927, **83**, 28–36.
18. HITCHCOCK, F. A., The Effect of Low Protein and Protein Free Diets and Starvation on the Voluntary Activity of the Albino Rat. *Am. J. Physiol.*, 1928, **84**, 410–416.
19. HODGE, C. F., Experiments on the Physiology of Alcohol Made under the Auspices of the Committee of Fifty. *Pop. Sci. Mo.*, 1896, **50**, 796–812.
20. HOSKINS, R. G., Studies on Vigor. II. Effect of Castration on Voluntary Activity. *Am. J. Physiol.*, 1925, **72**, 324–330.
21. HOSKINS, R. G., Studies on Vigor. IV. The Effects of Testicle Grafts on Spontaneous Activity. *Endocrinol.*, 1925, **9**, 277–296.
22. HOSKINS, R. G., Studies on Vigor. VI. The Effect of Starvation on the Spontaneous Activity of Castrated Rats. *Endocrinol.*, 1925, **9**, 403–406.
23. HOSKINS, R. G., Studies on Vigor. XII. Thyroid Administration in Senility. *Endocrinol.*, 1927, **11**, 136–140.
24. HOSKINS, R. G., Studies on Vigor. XVI. Endocrine Factors in Vigor. *Endocrinol.*, 1927, **11**, 97–105.
25. KUNDE, M., and NORDLUND, M., Studies in Metabolism. V. Inactivity and Age as Factors Influencing the Basal Metabolic Rate of Dogs. *Am. J. Physiol.*, 1927, **80**, 681–690.

26. LASHLEY, K. S., Studies of Cerebral Function in Learning. II. The Relation of Cerebral Injury to the General Activity of the Rat. *Psychobiology*, 1920, **2**, 68–73.

27. LEE, M. O., and VAN BUSKIRK, E. F., Studies on Vigor. XV. The Effect of Thyroidectomy on Spontaneous Activity in the Rat, with a Consideration of Basal Metabolism in Relation to Spontaneous Activity. *Am. J. Physiol.*, 1928, **84**, 321–328.

28. LIDDELL, H. S., Some Methods of Investigating the Effect of Thyroidectomy on the Neuro-Muscular Mechanism of Sheep. *Quart. J. Exp. Physiol.*, 1923, **13**, 191–197.

29. LIDDELL, H. S., and SIMPSON, S., The Effect of Thyroid Therapy on the Neuromuscular Activity of Cretin Sheep. *Am. J. Physiol.*, 1925, **72**, 63–68.

30. LIDDELL, H. S., The Relation Between Maze Learning and Spontaneous Activity in the Sheep. *J. Comp. Psychol.*, 1925, **5**, 475–483.

31. MILEY, H. H., Studies on Vigor. X. The Effects of Ovarian Extirpation on Fatigability of Muscle in the Rat. *Am. J. Physiol.*, 1927, **82**, 7–13.

32. NICE, L. B., Studies on the Effects of Alcohol, Nicotine, and Caffeine on White Mice. II. Effects on Activity. *J. Exp. Zool.*, 1913, **14**, 123–150.

33. PRICE-JONES, C., The Effect of Exercise on the Growth of White Rats. *Quart. J. Exp. Physiol.*, 1926, **16**, 61–67.

34. POWELSON, M. H., Gastric Transplantation. *Science*, 1925, N. S. **62**, 247–248.

35. RICHTER, C. P., A Behavioristic Study of the Activity of the Rat. *Comp. Psychol. Monog.*, 1922–23, **1**, No. 1.

36. RICHTER, C. P., A Study of the Effect of Moderate Doses of Alcohol on the Growth and Behavior of the Rat. *J. Exper. Zool.*, 1926, **44**, 397–418.

37. RICHTER, C. P., Animal Behavior and Internal Drives. *Quart. Rev. Biol.*, 1927, **2**, 307–343.

38. RICHTER, C. P., and WISLOCKI, G. B., Activity Studies on Castrated Male and Female Rats with Testicular Grafts in Correlation with Histological Studies of the Grafts. *Am. J. Physiol.*, 1928, **86**, 651–659.

39. SEHAM, M., and SEHAM, G., The Relation Between Malnutrition and Nervousness, II. *Am. J. Dis. Children*, 1929. (Now in press.)

40. SHIRLEY, M., Studies in Activity. I. Consistency of the Revolving Drum Method of Measuring the Activity of the Rat. *J. Comp. Psychol.*, 1928, **8**, 23–38.

41. SHIRLEY, M., Studies in Activity. II. Activity Rhythms; Age and Activity; Activity After Rest. *J. Comp. Psychol.*, 1928, **8**, 159–186.

42. SHIRLEY, M., Studies in Activity. III. The Influence of Phosphate Feeding on Activity; the Relation of Blood Sugar to Activity. *Am. J. Physiol.*, 1928, **83**, 377–383.

43. SHIRLEY, M., Studies in Activity. IV. The Relation of Activity to Maze Learning and to Brain Weight. *J. Comp. Psychol.*, 1928, **8**, 187–195.

44. SLONAKER, J. R., The Normal Activity of the Rat at Different Ages. *J. Comp. Neur. and Psychiat.*, 1907, **17**, 342–359.

45. SLONAKER, J. R., Description of Apparatus for Recording the Activities of Small Mammals. *Anat. Rec.*, 1908, **2**, 116–122.

46. SLONAKER, J. R., Normal Activity of the Albino Rat from Birth to Natural Death, Rate of Growth, and Duration of Life. *J. Anim. Behav.*, 1912, **2**, 20–42.

47. SLONAKER, J. R., The Effect of a Strictly Vegetable Diet on the Spontaneous Activity, the Rate of Growth, and the Longevity of the Albino Rat. *Stanford Univ. Publ.*, University Series, 1912, No. 9.

48. SLONAKER, J. R., Effect of Pubescence, Oestration, and Menopause on Voluntary Activity of the Albino Rat. *Am. J. Physiol.*, 1924, **68**, 294–316.

49. SLONAKER, J. R., Effect of Copulation, Pregnancy, Pseudo-Pregnancy, and Lactation on the Voluntary Activity and Food Consumption of the Albino Rat. *Am. J. Physiol.*, 1925, **71**, 362–394.

50. SLONAKER, J. R., Analysis of Daily Activity of the Albino Rat. *Am. J. Physiol.*, 1925, **73**, 485–503.

51. SLONAKER, J. R., Long Fluctuations in Voluntary Activity of the Albino Rat. *Am. J. Physiol.*, 1926, **77**, 503–508.

52. SLONAKER, J. R., The Effect of the Follicular Hormone on Old Albino Rats. *Am. J. Physiol.*, 1927, **81**, 325–335.

53. SLONAKER, J. R., The Effect of Different Amounts of Sexual Indulgence in the Albino Rat. II. Spontaneous Activity. *Am. J. Physiol.*, 1927, **82**, 376–380.

54. STEWART, C. C., Variations in Daily Activity Produced by Alcohol, by Changes in Barometric Pressure and Diet, with a description of Recording Methods. *Am. J. Physiol.*, 1898, **1**, 39–56.

55. SZYMANSKI, J. S., Eine Methode zur Eintersuchung der Ruhe und Aktivitätsperioden bei tieren. *Arch. f. d. ges. Physiol.*, 1914, **158**, 343–385.

56. SZYMANSKI, J. S., Aktivität und Ruhe bei tieren und Menschen. *Zeit. Allgem. Physiol.*, 1918–20, **18**, 105–162.

57. SZYMANSKI, J. S., Versuche über Aktivität und Ruhe bei Sangligen. *Arch. f. d. ges. Physiol.*, 1918, **172**, 424–429.

58. SZYMANSKI, J. S., Die Verteilung von Ruhe und Aktivitätsperioden bei einigen Tierarten. *Arch. f. d. ges. Physiol.*, 1918, **172**, 430–448.

59. WADA, T., An Experimental Study of Hunger in Its Relation to Activity. *Arch. of Psychol.*, 1922, No. 57.

60. WANG, G. H., Relation of Spontaneous Activity and Oestrus Cycle in the White Rat. *Comp. Psychol. Monog.*, 1923, **2**, No. 6.

61. WANG, G. H., RICHTER, C. P., and GUTTMACHER, A., Activity Studies on Male Castrated Rats with Ovarian Transplants and Correlation of the Activity with Histology of the Grafts. *Am. J. Physiol.*, 1925, **73**, 581–599.

62. WANG, G. H., and GUTTMACHER, A. F., The Effect of Ovarian Traumatization on the Spontaneous Activity and Genital Tract of the Albino Rat, Correlated with a Histological Study of the Ovaries. *Am. J. Physiol.*, 1927, **82**, 335–349.

63. WANG, G. H., The Effect of Thyroid Feeding on the Spontaneous Activity of the Albino Rat and Its Relation to Accompanying Physiological Changes. *Johns Hopkins Hospital Bull.*, 1927, **40**, 304–317.

RABAUD, ETIENNE. *How Animals Find their Way About.* N. Y.: Harcourt, Brace. 1928. ix+142 pp.

This is an extremely interesting and informative book concerning the general topic of homing. The author is thoroughly imbued with the law of parsimony. He refuses to admit any theory resting on the assumption of a mysterious sense or a supra-sensory faculty to explain the return of an animal to its habitation. His rejection of such hypotheses rests in the first place upon the methodological objection that such hypotheses are not open to research. This seems to the reviewer to be a very justifiable objection as one characteristic of a good hypothesis is that it opens the way for further investigation. His second reason for attacking such hypotheses is that they are unnecessary in order to explain any of the data at hand which have been collected in a scientific manner. The author believes that he can explain all these data in terms of the common senses possessed by the animal. The reviewer believes that he is successful in this attempt, especially for the invertebrates.

The author also warns against attributing to the animal our own sensations and perceptions. He agrees with Huxley ". . . that the observation of the movements of animals in no way requires a knowledge of states of consciousness. Without denying them, we do not take them into account: we do not assume their existence." "It remains true that he who wishes to do scientific work should avoid introducing into his research notions of which he cannot have direct experience, of which even the existence remains actually an unverifiable hypothesis."

The author believes that if the above attitude is adopted it removes the study of animal behavior from the field of psychology to the field of biology. He is surely cognizant of the fact that many American psychologists have adopted this attitude and are still studying animal behavior and still calling themselves psychologists. But after all, what difference does the name make?

After this preliminary discussion of the problem and method, the author proceeds to the consideration of the experimental work. It is perhaps a matter of some regret that about 79 per cent of the book deals with orientation in the vertebrates,—not that this section is too long but only that the section dealing with vertebrates is too short.

The author justifies this disportionate treatment by saying that far fewer sure data are known for the vertebrates than for the invertebrates. This is, of course, true but still it appears that some of the data concerning vertebrates might have been given fuller treatment. For example, the work of Watson and Lashley is given only one short paragraph. This is not written as a matter of criticism, for an author has the right to delimit his subject as he desires. It is simply an expression of disappointment that Dr. Rabaud has not seen fit to give us as complete a summary of the work with the vertebrates as he has for the invertebrates. This disappointment is only rendered the keener when a perusal of his writing concerning the invertebrates shows us the scientific acumen he is capable of in dealing with this subject.

This book impresses the reviewer as a masterpiece in the art of lucid scientific writing. It is truly an art to write in a clear and interesting manner and still have that which is written conform to the stern demands of science. Dr. Rabaud has done this to a remarkable degree.

W. T. HERON

University of Minnesota

WHEELER, W. M., *The Social Insects, Their Origin and Evolution.* N. Y.: Harcourt, Brace. 1928. xviii+378 pp.

This volume consists of a series of twelve lectures delivered by Dr. Wheeler at the University of Paris, and was originally published in France under the title, " Les Sociétés d'Insectes, leur Origine, leur Evolution," in the " Encyclopédie Scientifique." It is essentially a digest of the voluminous literature on social insects, together with a presentation of the author's conception of the characteristics of the social mode of life in insects, its origin and evolution in the various groups of social insects, and the significance and evolution of the various types of behavior characteristic of social insects. In his introductory remarks Dr. Wheeler explains the significance of the study of social insects to those other than entomologists as follows: " Fifth, I believe that the study of the social insects has, at the present time, a peculiar intereset to the serious student of philosophy, sociology, and animal behavior. Since we ourselves are social animals—I had almost said social insects—the philosophically inclined cannot fail to find food for thought in the strange analogies to human society, which continually reveal themselves among the wasps, bees, ants and termites, and the behaviorist will note that they suggest a bewilder-

ing array of fascinating facts and problems. Moreover, the very elaborate social behaviour of the insects, in that it is almost exclusively determined by the reflexes, tropisms, and the so-called instincts and not by intelligence, assumes great theoretical significance, when we contemplate the present anti-intellectualistic and relativistic tendencies and currents of European and American thought. We are beginning to see that our social as well as our individual behaviour is determined by a great background of irrational, subconscious, physiological processes."

The first lecture is introductory, and in it are to be found, among others, the theses: "That the behaviour of every animal, figuratively speaking, revolves about two axes, one of which is aggressive and individualistic, the other coöperative, or social"; that the "tendance associative" may be looked upon as an "appetition," and "thus takes its place with the other appetitions like hunger and sex, though it is feebler, more continuous, *i.e.*, less spasmodic and, therefore, less obvious"; "that all insect societies worthy of the name, and no matter how populous, are families, *i.e.*, affiliations of the parents and, in most cases, of the mother alone, with the offspring"; that the development of true social life in insects "is reached primarily through the development of an increased interest on the part of the mother in the later instars of her offspring and is, of course, made possible by a lengthening of her individual life span."

Lectures II–VI deal with the origins and evolutions of the main groups of social insects, the wasps, bees, ants and termites. In determining the course of evolution of these groups Dr. Wheeler not only utilizes the paleontological, morphological, taxonomic and biogeographical data, but also makes the fullest use of data on the comparative ethology of these insects.

Lectures VII and VIII discuss polymorphism, or caste development, its occurrence, possible origins in the various groups, significance and determination. Lecture IX is occupied chiefly with a discussion of the phenomenon of trophallaxis, the exchange of food among the members of the colony, which is considered of the greatest significance as a factor in the origin of social life, development of the castes, care of young and queen by workers, and attraction of guests and parasites. Dr. Wheeler expresses his concept of trophallaxis as follows: "If we compare the distribution of food in the colony regarded as a superorganism with the circulating blood current ("internal medium") in the individual insect or vertebrate, trophallaxis, as the reciprocal exchange of food between the indi-

viduals of the colony, may be compared with the chemical exchanges between the tissue elements and the blood and between the various cells themselves."

Lectures X and XI treat of the evolution of the numerous guests and parasites of social insects, and of the social insects which are themselves parasites of other colonies. The conclusion, Lecture XII, is occupied chiefly with a comparison between insect and human societies.

This work is an extremely valuable contribution to our knowledge of social insects. To say that it is well written, from the aspects both of science and literature, is unnecessary in considering its author. It is an excellent example of one of Dr. Wheeler's doctrines, that of emergent evolution. From a vast mass of unconnected and apparently unrelated observations, scattered widely in the literature of many countries, as is indicated by the bibliography of over eight hundred titles, have emerged a series of extremely important biological generalizations.

PHILIP A. READIO

St. Paul, Minn.

KARL J. HOLZINGER. *Statistical Methods for Students in Education.* Boston: Ginn, 1928. Pp. viii + 372.

This is an excellent text on the subject of statistical methods as applied to problems in education, very clearly and well written, containing clearly stated practical rules for carrying out and interpreting the various calculations and with just enough of the theoretical background for derivation of formulae to make them understandable but not enough to kill off the student who is not mathematically inclined. The book is useful also inasmuch as it contains short chapters on the use of logarithms, etc., which are usually presumed in most texts of this sort but in the use of which the usual student is woefully lacking. The text carries the student through linear, non-linear, partial and multiple correlation and the elements of curve fitting.

SAMUEL W. FERNBERGER.

University of Pennsylvania

CHRISTIAN A. RUCKMICK. *German-English Dictionary of Psychological Terms.* Iowa City: C. A. Ruckmick, 1928. Pp. 45.

This little book containing over 1,200 English equivalents of German psychological terms should be in the hands of everyone who is reading psychological German. The words translated are not confined to psychology but include words from other sources (sta-

tistical, physiological, etc.) which frequently occur in psychological books and articles. The need of this work is apparent when one considers that it is the first thing of its kind since the Titchener list, published in 1895, which is still useful but by now entirely incomplete.

SAMUEL W. FERNBERGER.

University of Pennsylvania

CHRISTIAN A. RUCKMICK. *The Mental Life: A Survey of Modern Experimental Psychology.* New York: Longmans, Green, 1928. Pp. ix + 253.

This short and interestingly written elementary text-book defines psychology as the science of experience,—substituting the term observation for the more classical introspection and thus placing our study of mental life on a par with the other observational sciences. Brief chapters discuss sensory and perceptual experience, imaginal and affective experience, attention, association, action, thought and self. At the end of each chapter is a summary, review questions, and a selected bibliography. At the end of the book there is a classified bibliography for thirteen "fields" of psychology. It seems to the reviewer unfortunate that, in view of the subtitle, more references to experimental literature were included at the expense of so many references of a systematic nature.

SAMUEL W. FERNBERGER.

University of Pennsylvania

A. M. JORDAN. *Educational Psychology.* N. Y.: Holt, 1928. Pp. xiv + 460.

The text is divided into four parts. The first is concerned with problems involved in learning the school subjects in which the author discusses methods, the inherited background of the learner and the principles and conditions of learning. Chapters are added on how to study and a good deal of space is given to the general problem of transfer of training. In Part 2 the author takes up the problems concerned with individual differences in which he treats the effects of intelligence differences, racial differences and the like. Part 3 considers the question of intelligence and educational tests. Part 4 is concerned with problems involved in learning habits of conduct,—those of the maladjusted child and problems of discipline arising from backward and retarded children. The book contains a great deal of tabular and statistical data, so that the student may study these at

first hand in the light of the interpretation given, and a great many references.

SAMUEL W. FERNBERGER.

University of Pennsylvania

IVAN P. PAVLOV. *Lectures on Conditioned Reflexes.* (Trans. from the Russian by W. H. Gantt with the collaboration of G. Volborth. Intro. by W. B. Cannon.) N. Y.: International Pub., 1928. Pp. 414.

American Psychologists and Physiologists will welcome the appearance in English of the present volume which contains all of the lectures which appeared in the German translation as well as two added ones on A Psychological Study of the Types of Nervous Systems, *i.e.,* of Temperaments and Certain Problems in the Psychology of the Cerebral Hemispheres.

The conditioned reflex work of Pavlov is too well known by American Psychologists to need description. This book is not only important in describing the experimental work that has been done in Pavlov's laboratory, but it is also interesting as showing the historical, progressive development of the problems as developed by Pavlov. The book really contains forty-one lectures and abstracts of lectures delivered personally before scientific societies in Russia and elsewhere and is therefore really a series of reports of progress running from 1903 to 1928. The development and enlargement of the idea of conditioned reflex as the problems developed was personally interesting to the reviewer. Starting with the work of the Salivary Reflexes, the author develops to the point of lecturing on the Reflex of Purpose in 1916, the Reflex of Freedom in 1917, and Temperaments in 1928.

The book also contains an interesting biographical sketch of Pavlov with some informal pictures and a complete bibliography of the writings published from the Pavlov laboratory,—all translated into English titles.

SAMUEL W. FERNBERGER.

University of Pennsylvania

Studies from the Physiological Laboratory of I. P. Pavlov. 1925, 1, No. 1; 1926, Nos. 2 and 3; 1927, 2, No. 1. National Press, Leningrad (Russian).

These three issues of "studies" contain original experimental work by students of Pavlov. Altogether, there are 28 articles.

The material contained in these issues is very interesting for the most part. The work has been done with dogs exclusively and by

the method of conditioned response. It is difficult, of course, to give a specific account of the nature and scope of the various investigations, since they touch upon nearly all of the most important findings of the Russian physiologists in the last twenty years.

The dominant impression left in the mind of the reader as he goes through these issues is one of aridity as far as systematic implication is concerned. In other words, it is "variations on a theme" which calls to mind much of the routine work on learning done after Ebbinghaus, and, in the animal field, after Thorndike. It is true, the writers now and again give to understand that learning of any type is nothing but a series of conditioned reflexes; but the mere verbal statement is not very helpful. All of the experimental results are explained in terms of inhibition, reënforcement, negative and positive induction; but there seems to be no attempt to apply these concepts to the more natural behavior of animals in their normal environment. The writers themselves would probably justify their method of approach by pointing out that their interests are more or less physiological in the strict sense.

Volume 1, Nos. 2 and 3, and Colume II, No. 1, contain résumés in German which are helpful to the reader unacquainted with Russian.

The "studies" are filled with references to earlier work done in Russia, and thus present a good bibliography to anyone wishing to make a systematic study of the Russian work.

J. A. GENGERELLI.

Yale University

A. G. IVANOV-SMOLYENSKI. *Methods for Investigating the Conditioned Reflexes in Man.* (Russian.) Press of Practical Medicine, Leningrad, 1928.

This monograph of a little over a hundred pages is a valuable survey of the methodological developments which have grown out of Pavlov's now classic work.

The work is devoted to a detailed description of the various methods and types of apparatus employed by Russian physiologists and psychologists for objective studies of the conditioned reflex type. The minute care given to experimental set-up and control particularly strike the reader. The text is replete with diagrams and photographs so that the reader at no time loses his way in a maze of technical description.

A glance at parts of the table of contents will give a better idea of the nature of the work: Investigation of the conditioned salivary reflex; Investigation of the conditioned vasomotor reflex; Investigation of the conditioned motor reflex; Construction and equipment for a laboratory devoted to the study of the conditioned reflex in man; Methods for setting up positive and negative conditioned reflexes in man; Methods for studying conditioned verbal reactions, etc., etc.

The only reproach that can be placed against the author is the distressing glibness with which he uses the term conditioned reflex; everything is conditioned reflex for him,—even replying to questions of the experimenter. At all events, the Russians take their conditioned reflexes seriously. "We therefore see," the author concludes, "that the fact of the conditioned reflex, besides having methodological significance, constitutes the foundation of . . . human behavior, and presents a great interest for a whole series of other scientific disciplines."

A bibliography of forty-one titles is appended, as well as a list of the leading Russian psychological periodicals.

Yale University J. A. GENGERELLI.

E. AUGIER. *Une Psychologie Objective est-elle Possible.* Paris: Alcan, 1928. Pp. 290.

In the introduction and opening chapters this book seems rather promising, but as the theme progresses, it ranges itself with the class of writings which rest their case and their hopes on that gratuitous method of postulating remarkable neural processes to explain psychological facts.

The author begins by inveighing against the "classical psychology," pointing out its shortcomngs and lack of connection with the objective sciences. He repeatedly calls attention to its persistent tendency of failing to set its problems and solutions in terms of time and space. This, he argues, is the unique task of an objective psychology. But when he goes on to his solution and takes up in turn the simpler sensory and affective processes, the reader becomes gradually disillusioned. For the writer proceeds as if James, Dewey, Bechterev and Watson had never written.

Augier takes what he calls the "internal sense" as his starting point; introspects; then proceeds to "neurologize." Feelings and emotions are abortive primitive reflexes. Sensations and images

are internal [implicit (?)] discharges of sets of neurones plus incipient movements of the sense organs involved. When he gets to the higher processes, he invokes the complexity of the central nervous system, and talks of speech, auditory and visual reflexes and their associations, reservoirs of nervous energy and what-not, all with the most distressing vagueness. He apologizes now and then by pointing out the scantiness of our neurological and physiological knowledge. It makes one think of Horwicsz.

The author repeatedly points out that psychology should be a science dealing with trains of determined events in the nervous system, rather than with vague descriptions of the experiences of a finished ego. All of which has not been doubted by the majority of psychologists in the last forty years at least. Certainly the earnest criticism which he directs at Bergson seems to indicate that he takes that writer's position much more seriously than is usually the case among psychologists.

His analyses on the introspective side are likewise facile, and the work ends, for the modern reader, just where it started.

J. A. GENGERELLI.

Yale University

THE INFLUENCE OF LETTER POSITION ON RANGE OF APPREHENSION—A REPLY TO DR. TINKER

BY H. R. CROSLAND
University of Oregon

Inasmuch as a certain misapprehension seems to have entered Tinker's recent review[1] of a study[2] of the range of visual apprehension by Miss Georgia Johnson and myself, I should like the usual courtesies of being allowed to make a reply.

On page 227 of the review Tinker has stated that "this" (the employment of series of letters of various lengths, from 3 to 10) "undoubtedly favored the" discovery by us of a descending effectiveness of the letters from left to right on the exposure cards, "for responses are more uniformly correct with the shorter series in visual apprehension work. This, of course, would tend to give more correct" (p. 228) "responses to the positions at the left when all results are considered together." I interpret this statement to mean that, since 10 letters include the 3 at the left, 9 letters include the left 3, and so on, and since there was a series with only 3 letters, and others with 4, and so on, the pooled results were so heavily weighted with the three's, four's, and five's, that it was inevitable that the three first positions should show high scores: greater possibilities of high scores were afforded by the very high frequencies of letters occupying positions 1, 2, and 3 on the exposure cards. I interpret his statement, moreover, to mean that the curve of the diminishing effectiveness of positions from left to right should in our results correspond with the curve of the numbers of letters or with the curve of the possible (maximum) scores.

With such an interpretation, I reply with eight points:

1. All groups of letters (3's through 10's) were printed each in the center of its card (not so explicitly stated, but inferable from a knowledge of printing customs and from pages 85 and 86 of our paper).

2. The subject was instructed on three different occasions in each

[1] This JOURNAL, 1929, 26, 227f.

[2] The Range of Apprehension as Affected by Inter-Letter Hair-Spacing and by the Characteristics of Individual Letters. *J. Appl. Psychol.*, 1928, 12, 82-124.

observation to fixate the center of the lighted, exposure area (field) (page 87ff., our paper).

3. Each card, bearing any group of letters, was presented in the center of the fixation field; consequently, the middlemost letter was in the center of the field; and hence, positions 1, 2, and 3 on the various cards came at various places with respect to center for the various series (it is true that these positions were never changed from the relationship just described, such as to place them to the extreme right or the extreme left of the card or fixation field) (our paper, page 87f).

4. The various series of letters (3's, 4's, etc.) were presented in an entirely random or chance order, consequently practice-effects and other preferential considerations were not allowed to accrue to the smaller series, such as the 3's, 4's, and so on.

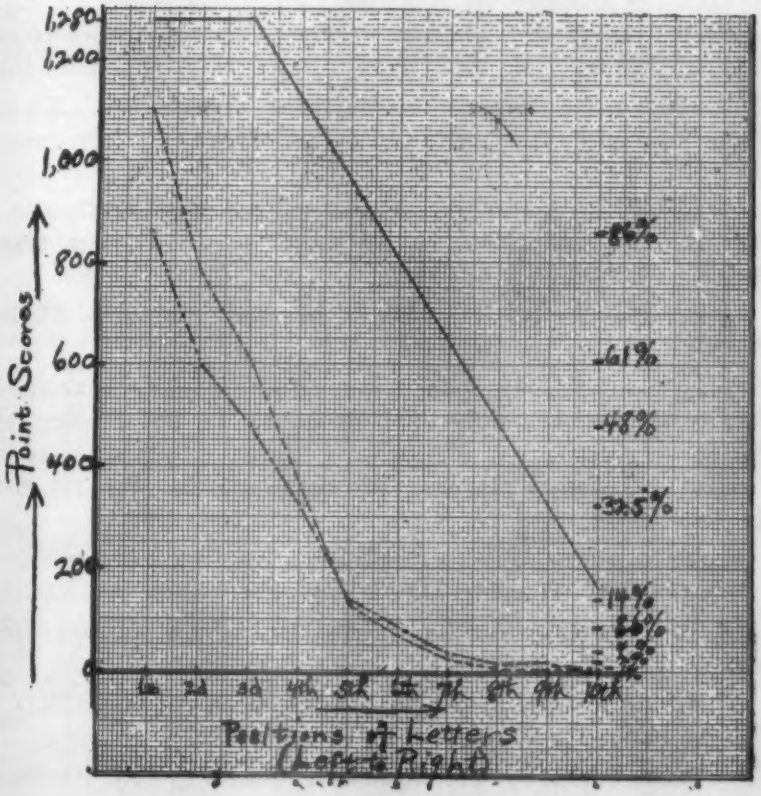
5. The graphs presented herewith tell at least four stories: (a) a 3-letter card bore letters occupying positions 1, 2, and 3, respectively; all other cards had positions 1, 2, and 3 occupied by letters; and since the maximum scores are the same for these three positions, our results (both by absolute and by percentage scores) are at great variance with Tinker's expectations. (b) For positions 8, 9, and 10 both sets of obtained scores are at great variance with the possible scores depending solely upon the construction of the series. Curves for the former two make an angle of approximately 55 degrees with the curve of the latter. (c) For positions 3, 4, and 5 there is some parallel with expectations from a basis of the maximum possible scores, but a parallel also made possible by the size of the average subject's range. And (d) from position 5 through 8, this parallel, however, ceases to be discoverable; in fact the whole course of the curves of obtained scores resembles far more a usual learning curve or any logarithmic curve than either resembles a curve based solely upon the construction of the cards themselves, since the latter contains only two straight lines and the last one being indicative of mere arithmetical progression.

I may say, finally, that if our subjects possessed habits of reading from left to right, in exposure periods of only 150σ, such habits accounting for our results, no power lay in our hands by which we could prevent such an occurrence. If the tachistoscopic technique, with exposure periods of no more than 150σ, cannot prevent this habitual order of reading, we are sure that non-tachistoscopic techniques give no promise of more competent results.

THE RELATIVE FREQUENCIES OF POSSIBLE (MAXIMUM) SCORES, EARNED ABSOLUTE SCORES, AND EARNED PERCENTAGE (%) SCORES, FOR ALL POSITIONS OF LETTERS ON EXPOSURE CARDS FROM LEFT TO RIGHT (1ST–10TH), IN CROSLAND'S AND JOHNSON'S STUDY OF THE RANGE OF APPREHENSION, ETC. (*J. Appl. Psychol.*, Feb., 1928, pages 97f.)

SERIES I–A

———— = Possible (Maximum) Scores
- - - - - - - - = Obtained, Absolute Scores
——- - —- - = Obtained, % Scores



BOOKS RECEIVED

Serving the Child in Fargo. Part III of the Final Report of the Fargo Demonstration. Commonwealth Fund Div. of Pub., Bull. No. 9. N. Y.: 1928. Pp. 127.

GARDNER MURPHY, *An Historical Introduction to Modern Psychology.* (Supplement on Contemporary German Psychology by Heinrich Klüver.) N. Y.: Harcourt, Brace, 1929. Pp. xvii+470.

Feelings and Emotions. The Wittenberg Symposium. (Ed. by M. L. Reymert.) Worcester: Clark Univ. Press, 1928. Pp. xvii+454.

HARRY L. GILCHRIST, *A Comparative Study of World Casualties from Gas and Other Weapons.* Edgewood Arsenal: Chemical Warfare School, 1928. Pp. vi+51.

HARVEY FLETCHER, *Speech and Hearing.* (Intro. by H. D. Arnold.) N. Y.: Van Nostrand, 1929. Pp. xv+331.

N. KOHTS, *Adaptive Motor Habits of the Macacus Rhesus under Experimental Conditions. A Contribution to the Problem of "Labour Processes" of Monkeys.* (Russian with a summary in English.) Moscow: Museum Darwinianum, 1928. Pp. 368 with 24 plates.

CARL MURCHISON, *Social Psychology.* The Psychology of Political Domination. Worcester: Clark Univ. Press, 1929. Pp. x+210.

J. R. KANTOR, *An Outline of Social Psychology.* Chicago: Follett, 1929. Pp. xiv+420.

THOMAS MUNRO, *Scientific Method in Aesthetics.* N. Y.: Norton, 1928. Pp. xi+101.

J. BAAR, *Psychology* (for Reviews). (Intro. by C. J. Warden.) N. Y.: Globe Book Co., 1928. Pp. vii+126.

RADHAKAMAL, MUKERJEE & NARENDA N. SEN-GUPTA, Introduction to Social Psychology. (Foreword by J. Davis; Intro. by R. M. Yerkes.) Boston: Heath, 1928. Pp. xv+304.

AARON J. ROSANOFF (Ed.), *Free Association Test* (Kent-Rosanoff). 6th Ed. N. Y.: Wiley. Pp. 546–620.

MARY CHADWICK, *Difficulties in Child Development.* N. Y.: Day. Pp. 411.

ELMER T. CLARK, *The Psychology of Religious Awakening.* N. Y.: Macmillan, 1929. Pp. 170.

DANIEL S. ROBINSON, *An Anthology of Recent Philosophy.* Selections for Beginners from the Writings of the Greatest 20th Century Philosophy. N. Y.: Crowell, 1929. Pp. xi+674.

NOTES AND NEWS

THE announcement was made by Yale University on February 15th of the establishment of an Institute of Human Relations. Gifts have been received from several of the Foundations for a building, to be erected at the cost of $1,500,000 and endowment for ten years representing the income on $6,000,000. The project will involve the coöperation of all of the departments of the University that are interested in the human being. Facilities will be provided in the building for about fifty individuals whose prolonged residence in the Institute will be essential for investigations in psychiatry, child development and psychology. One wing of the building will be devoted to research in child development, under the direction of Dr. Arnold Gesell. The present Institute of Psychology at Yale University which includes in its personnel Professor R. P. Angier, chairman, and Professors R. Dodge, C. Wissler and R. M. Yerkes will be housed in the new building. Facilities will be provided for research in all phases of psychology, including comparative, genetic and ethnic psychology, anthropology and the development of instruments of precision needed in experimental work.

THE Board of the National Research Fellowships in the Biological Sciences has announced the awarding of fellowships in psychology: reappointment, A. Rizzolo; new appointments, J. F. Brown, G. LaV. Freeman, W. N. Kellogg, and W. D. Turner.